# VEGETATION-BASED VALORIZATION OF DEGRADED MINE SOILS: A DENSITY-OPTIMIZED MUCUNA PRURIENS APPROACH FOR SUSTAINABLE MINERAL WASTE REMEDIATION

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**Abstract:**

Mineral waste generated from artisanal and small-scale mining presents a major environmental challenge across sub-Saharan Africa, often resulting in degraded soils with low fertility and elevated concentrations of potentially toxic elements. Developing cost-effective and scalable strategies for transforming such waste into functional substrates is critical for sustainable land management. This study evaluates the potential of Mucuna pruriens as a biological tool for the valorization of degraded mine soils through density-optimized remediation. The study was conducted on an abandoned mined site characterized by strong acidity (pH 4.95), low available phosphorus (5.24 mg $kg^{-1}$), low total nitrogen (0.05%), and very low organic carbon (0.09%), alongside elevated exchangeable aluminium (0.97 cmolc $kg^{-1}$). A randomized complete block design with five planting density treatments (T1–T5) was implemented over two cropping cycles. Significant improvements ($P \leq 0.05$) in soil properties were observed. Soil pH increased by 10–15%, while exchangeable aluminium and hydrogen decreased by up to 30% and 25%, respectively. Nutrient recovery was substantial, with available phosphorus increasing to moderate levels, total nitrogen increasing by 80–200%, and organic carbon improving by up to 70%. Concurrently, trace and potentially toxic elements declined significantly across treatments. Arsenic and cadmium decreased by 20–36% and 25–35%, respectively, with consistent reductions in lead and mercury. Moderate to wider planting densities (T3–T5) achieved the greatest improvements. The findings demonstrate that Mucuna pruriens can effectively transform degraded mine soils into more functional substrates, providing a low-cost and scalable pathway for sustainable mineral waste remediation and land reuse.

**Keywords:** Mine Soil Remediation, Mucuna pruriens, Mineral Waste Valorization.